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School of Naval Warfare: Where Shall We Build the new Sea-Level Canal?

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INTRODUCTION

The Panama Canal is nearing the end of its days, and the need for a new canal is growing as each year passes. Over the last ten years commercial traffic transiting the canal has climbed from 36 million tons to 70 million tons annually. Today, some ships lie to for 15 hours or more waiting to pass through the canal. The supertankers, large ore carriers, and most of our aircraft carriers cannot squeeze through it at all. With the trend toward the construction of larger aircraft carriers and the supertankers now being built in Japanese shipyards, canal experts predict that by the year 2000 the Panama Canal will be obsolete, and that by 1975, or perhaps sooner, there will be a monumental traffic jam at the Canal.

Prior to World War II many plans for increasing isthmian canal capacity were proposed by various

government agencies and congressional committees. Since the War, approximately 30 sites have been considered for a sea-level canal without locks. In December 1964, President Johnson announced that four sites for the construction of a canal would be given serious consideration by the United States, and that this country would press forward with Panama and other interested governments in plans and preparations for a sea-level canal in Latin America. Two of the sites are in Panama, one is in Colombia, and the other passes through Costa Rica and Nicaragua.

Our political and economic position in Latin America, as well as our strategic posture in the Western Hemisphere, particularly in the Caribbean area, should not be downgraded. Therefore, a program to build a transisthmian canal should be pushed with deliberate speed.

In order to insure that the best interests of the United States are served, however, careful consideration must be given to a myriad of political, economic, military, and technical feasibility factors before the final site for the canal is selected.

The purpose of this paper is to discuss the historical, political, economic, and operational factors associated with the Panama Canal; to examine the strategic significance, the vulnerability, and the physical restrictions of the canal; to consider financial and political aspects associated with or affecting the construction of a sea-level canal; to analyze the feasibility of using nuclear devices to dig a trench for the canal; to examine the various plans for a sea-level canal, citing advantages and disadvantages of each route; and finally to recommend a route which will meet the needs and best serve the interests of the United States.

I—THE PANAMA CANAL

History. The story of the Panama Canal began 452 years ago when Balboa stumbled across the Darien jungle and discovered the Pacific Ocean on 25 September 1513. Although the idea for an interoceanic canal was not Balboa's, his discovery provided the impetus, or led to the first investigations for a canal route across the American isthmus. In 1529 Alvaro de Saavedra Ceron completed a survey of four possible routes which are still being considered as possible sea-level routes across the isthmus.[1] Charles V of Spain, in

1534, grasping the significance of a canal to join the Atlantic and the Pacific, ordered a formal survey to be made along the general route of the present canal. Baron von Humboldt, the famous German explorer who visited Central and South America at the turn of the 19th century, recommended nine possible routes across the isthmus. Included in his recommendations were the Atrato River route in Colombia and the San Blas route south of the existing canal.[2]

America's interest in a transisthmian canal had been expressed by early statesmen, such as Benjamin Franklin, Henry Clay, and John C. Calhoun, but it was not until 1880 that our policy concerning a canal across the isthmus was firmly established. On 8 March 1880 President Hayes stated that ". . . the policy of this country is a canal under American control."[3] In his message to Congress the following December, Hayes proclaimed that it was the duty and right of the United States to assert and maintain such supervision and authority over any interoceanic canal as would protect our national interests.[4]

In 1881 a French company, under the leadership of Ferdinand de Lesseps of Suez Canal fame, made the first attempt to build the Panama Canal. The French company failed to consider the serious effect of tropical diseases, and after a gallant struggle against overwhelming odds of heat, disease, jungle, mountains, and financial mismanagement, went bankrupt in 1899 before two-fifths of the work was done.

A series of historical events commencing with the appointment of the first Isthmian Canal Commission by President McKinley in 1899, recommendations for a sea-level canal through Nicaragua, the sale of the French Canal Company properties to the United States for $40 million in 1904, the Spooner Act authorizing construction of the canal, and the negotiation of a treaty with Colombia for canal rights, finally culminated in the best-known imperial experiment of the United States--the construction of the Panama Canal. The construction period covered about ten years, but the actual excavation work was done in seven years. On 3 August 1914 the first vessel, the *Cristobal*, passed through from ocean to ocean. Transit of the *Ancon*, a sister ship, on 15 August 1914 marked the official opening of the Canal to regular ocean traffic.

Economic Importance. The first consideration in an economic evaluation of the Panama Canal should

include factors relating to distance, time, and ship-operating costs. In 1965 the average vessel transiting the Canal paid about $5,100 in tolls. If these same vessels were required to sail around the tip of South America from New York to San Francisco, for example, shipping costs would skyrocket to about $50,000, distance would increase by 7,000 miles, and sailing time would be extended by about 20 days. It is estimated that the aggregate savings to ships using the Panama Canal in operations alone amounts in one full year to as much as $150 million.[5]

Since the Canal opened to traffic in 1914, over 340,000 vessels have transited, and over 1.3 billion tons of cargo have been carried through by ships of all nations. In the last ten years traffic has climbed from about 36 million tons to about 70 million tons a year.[6] In 1964 Canal traffic and transits reached an all-time high when 70,550,000 long tons of cargo passed through the waterway in 12,184 vessels. The Stanford Research Organization has predicted that by 1975 tonnage will approach about 73,500,000 long tons.[7]

The ever-increasing importance of the Canal to the United States, to world commerce, to the economic development of Latin America, and to the very survival of Panama is shown by the following: Over 70 per cent of the total commercial cargo transiting the Canal originates in, or is destined for, the United States. Five per cent of the total seaborne commerce of the world utilizes the Canal. About 88 per cent of Ecuador's waterborne exports and 77 per cent of her imports go through the Canal.[8] Peru and Chile depend on the Canal for approximately the same percentages in their oceangoing commerce. Even countries in the Far East like Japan ship about 50 per cent of their exports to the West through the Canal. Finally, virtually 100 per cent of Panama's revenues, which approximate $90 million annually, are generated by the Canal.[9]

Strategic Significance. Even before the Panama Canal was constructed, the military or strategic importance of an interoceanic highway across the American Isthmus was recognized by the United States. Thirty years before work on the Panama Canal was completed President Hayes announced to the U.S. Senate that a canal's relation to U.S. power and prosperity as a nation, to its means of defense, its unity, peace, and safety, are matters of paramount importance to the people of the United States.[10]

It was not until the emergence of the United States as a world power, however, that the strategic value of a transisthmian canal was firmly established in the White House, in the Congress, and in the American press. One of the most dramatic events of the Spanish American War was the 90-day race of the battleship *Oregon* from the Pacific around Cape Horn to the battle of Santiago de Cuba. This, more than any other factor, pointed up America's military requirement for an isthmian waterway.

Other factors which had a bearing on the military importance of a canal included the territorial expansion of the United States in the Pacific and the Cuban question. These factors and events provided the Mahans, the Roosevelts, and the Lodges of this era with a convenient vehicle to promote the "large policy" which advocated securing control of the isthmus and its maritime approaches from both oceans. As expressed by Mahan in 1914, the Canal's purpose was to provide the Navy with a means of communication between the Atlantic and the Pacific.[11] In other words, the objective of Mahan's canal was to facilitate the disposition of the fleet and to maintain a two-ocean Navy.

The progression of events since the opening of the Canal in 1914--World War I, World War II, the Korean Conflict, the Cuban Crisis, and the war in Southeast Asia--has proved, over and over again, that the Isthmian lifeline has enabled the United States to maintain a position of supremacy in the Western Hemisphere and in many areas of the world. During World War I the Canal served as a supply line to fighting forces in Europe. During World War II more than 5,300 combat vessels and 8,500 other ships transporting troops and cargo transited the Canal with incalculable savings to the allied nations in terms of time, money, and lives. The strategic value of the Canal was again demonstrated during the Korean conflict, when in 1953, the last year of the police action, 1,064 U.S. Government ships passed through the Canal carrying supplies and war material to the United Nations forces in the Far East.[12] In 1962, during the Cuban crisis, it was necessary to move key amphibious units from California to Cuban waters. On 6 November 1962, 17 warships, with these units aboard, passed through the Canal, while commercial traffic was halted.[13] Today, the Canal is providing a shortcut for naval units and cargo vessels that are moving from the East Coast and from Gulf ports to the South Pacific theater of operations.

Ironically, one of the major purposes for the construction of the Panama Canal--to provide the means for facilitating the mobility and disposition of the fleet--is inhibited today by the size of the locks which precludes the passage of modern aircraft carriers. Even with this limitation, however, the Navy's position concerning the Panama Canal has not changed substantially since Admiral Mahan's pronouncement in 1914. In testimony before a Congressional Subcommittee on Inter-American Affairs in 1960, Adm. James S. Russell, then Vice Chief of Naval Operations, declared that the Panama Canal is now and will continue to be of great importance to the Navy and to this country. He said that this importance derives from incontrovertible facts of geography, economics, and time. He added that today, more than ever before, the United States and its allies depend on the seas for economic life and for military strength. Moreover, the Panama Canal is an essential link in the long sealines which connect and hold together the free nations of the world, and that, militarily, the Canal provides the flexibility to deploy forces rapidly to meet a threat in either ocean, and to support these forces logistically with maximum efficiency and effectiveness.[14]

Vulnerability. A lock-type waterway of the Panama Canal's magnitude is extremely vulnerable to both conventional and nuclear attacks. Even before the Canal was built, the danger of sabotage by damaging the locks was recognized. In 1904 a consulting board of engineers reported that ". . . it is well nigh impossible to provide effectively and always against such a peril."[15] Since it was opened to traffic in 1914, the defense of the Canal against sabotage or attack has been a problem to Canal authorities. During World War I both the Army and Navy were charged with the defense of the Canal. In 1932 the Army claimed that no proper military protection of the Canal could be devised.[16] However, during World War II the defense of the Canal was accomplished by concentrating some of our naval strength on the Pacific side of the Canal, stocking extra gates for the locks, and bolstering local defenses with outer and inner patrols of radar-equipped planes and a land-based aircraft warning system.[17] Today the defense of the Panama Canal is not much different from what it was in World War I. Protection is still furnished by the Navy and the Army.

Destruction of the locks at Gatun, Pedro Miguel, or Miraflores would put the Canal out of commission for several months. Dropping a span of the new Thatcher Bridge over the Pacific end of the Canal would temporarily halt traffic. Breaching the Madden Dam which impounds the waters of Gatun Lake, could spill the lake into the sea and effectively close the Canal. Furthermore, inducing slides in Galliard Cut could also stop traffic. All of these possibilities could be readily accomplished with a relatively small amount of high explosives placed in the proper location at the locks, the bridge, the dam, or at Galliard Cut.

With regard to nuclear weapons, in this era of the intercontinental ballistic missile, almost any item on earth with a fixed address is vulnerable. In recent tests in the Soviet Union and in the South Pacific, the Russians have demonstrated that they have the capability of delivering a nuclear-tipped ICBM to the Panama Canal from the Soviet landmass. Moreover, it is probable that the U.S.S.R. has a capability to deliver nuclear weapons from Polaris-type submarines.

In the final analysis, it should be pointed out that the distinction made between the vulnerability of the Canal to conventional versus nuclear weapons is academic. The use of either weapon can effectively put the Canal out of commission. Further, if and when a nuclear war does come about, it is unlikely that the Panama Canal will be a primary target. It is conceivable the enemy might entirely overlook the Panama Canal and concentrate on industrial targets and military bases in the United States, according to Admiral Russell, who testified along these lines in 1960 before a congressional committee on foreign affairs.[18] Writing in *The New York Times* in 1957, the noted authority on military affairs, Hanson Baldwin, said that the Canal today is indefensible in total war, and short of total war, is less defensible than ever before.[19] Today, eight years later, the military posture of the U.S.S.R. the absence of an effective antiballistic missile, and the susceptibility of the Canal to sabotage in a limited conflict, tends to give some credence to the 1957 analysis of Mr. Baldwin.

Physical Restrictions. The Panama Canal, a lock-type waterway connecting the Atlantic and Pacific Oceans through the Isthmus of Panama, traverses a distance of approximately 51 miles. In traversing the

Canal vessels are raised in three steps to the 85-foot level of Gatun Lake and lowered in three steps to the level of the Pacific Ocean. The greatest part of the Canal channel is at the Gatun Lake level with a minimum width of 300 feet and a minimum depth of 42 feet. Each of the lock chambers in each flight of locks has a length of 1,000 feet, a width of 110 feet, and a depth of 70 feet. This is, in essence, the official description of the Panama Canal as expressed by the Panama Canal Company. The limitations or physical restrictions are inherent in this description.

Specifically, the major physical restrictions at the Canal are lock limitations and channel restrictions. In general, other limitations are the result of, or are caused by, these major restrictions. Climatic factors, such as fogs in the Galliard Cut, also limit the capacity of the Canal. With regard to the locks, the maximum dimensions considered safe for commercial vessels passing through the waterway are: 800 feet in length, 102 feet in beam, and 37 feet in draft. Although larger vessels have transited under emergency conditions, any vessel exceeding these dimensions will not be permitted to transit the Canal. Today the United States has 25 naval units which cannot use the Canal. In addition, there are about 50 commercial vessels too large for the Canal and over 550 commercial ships which cannot go through fully laden.[20]

The channel restriction factor applies to the Galliard Cut where a minimum width of 300 feet poses navigation problems for certain vessels. Such vessels are classified as "clearcut" ships because they need a clear channel to navigate the cut. A vessel of this category is usually one carrying explosives or dangerous cargo. During the transit of one of these vessels, other ships are not permitted to use the cut moving in the opposite direction. Furthermore, some of these ships cannot safely transit the cut at night. As a result, the delay in normal traffic at the Canal because of the "clearcut" transit restrictions varies from two to three hours.

In summary, both physical restrictions and operational factors limit the capacity of the Canal. These factors include the following: restricted dimensions in the Galliard Cut; the number of lockages that can be completed in a day; the number of daylight hours during which certain ships can pass

through the Galliard Cut; the necessity for single-lane operation during lock overhauls; the necessity for single-lane operation in the event of accidents in lock chambers or failure of structures or locks' operating machinery; the arrival of unusual numbers of large vessels or ships requiring "clearcut" treatment; imbalance of north-south transits; and occurrence of fog, rain, and unusual wind velocity.[21]

Proposed Improvements. A number of short-range improvement projects to increase capacity by expediting the movement of ships in transit have been instituted at the Canal. These include the widening and deepening of the Galliard Cut from 300 to 500 feet, the installation of modern lights along the cut and at the locks, the provision of mooring facilities north of the Pedro Miguel locks, the acquisition of new towing locomotives and cranes, and the installation of an electronic ship-dispatching and marine-control system to permit maximum use of the locks.[22] In addition, the construction of a dam across the Trinidad arm of Gatun Lake to increase the water supply of the Canal for shipping and power requirements has been proposed and approved. Work on the dam is scheduled to commence in fiscal year 1966.[23] The completion of these projects, most of which have been underway since 1954, is expected to make it possible for the Canal to handle all anticipated traffic until the year 1980. The Canal's capacity problem, however, also involves a significant growth in vessel size as well as a steady increase in the number of transits. Consequently, the short-range plans are only interim or makeshift remedies and have been complimented by several long-range plans to increase the capacity of the Canal.

The long-range program for the Panama Canal considers further modification of the existing Canal and conversion of the present Canal to sea level. Plans include the following: interim improvements to the present Canal, a third-locks canal, a consolidated third-locks canal, and a zone sea-level canal.[24]

The interim improvement plan is essentially the short-range program which is currently under development with some modifications, such as increasing channel depths and modifying the locks.

The third-locks project involves the completion of the third locks which were initiated in 1940 and suspended in 1942. These locks would have 1,200-foot lengths, 140-foot widths, and 50-foot depths. They

would provide a third lane and be able to pass much larger vessels than can be accommodated today. The reconstruction of the Panama Canal in accordance with this plan would provide a lock canal capable of handling practically all commercial shipping through the year 2000.[25]

The consolidated third-locks plan calls for lock chambers 1,500 feet long, 200 feet wide, and 50 feet deep, with the Pacific locks concentrated at Miraflores and the Pedro Miguel locks eliminated. With the elimination of these locks, Miraflores Lake would be raised to the level of Gatun Lake and would provide a summit anchorage. The channel would be widened to 500 feet and would have a minimum depth of 55 feet. This plan would handle most of the commercial vessels anticipated but would not allow passage of the *Forrestal*-class aircraft carrier.[26]

The zone sea level plan envisions a 600 footwide channel with depths of 60 feet. It would follow the general alignment of the present Canal, and the total length of the waterway would be reduced from 51 to 46 miles. Flood control structures would be built to regulate and divert flows of all streams tributary to the Canal. The changeover from the present Canal to sea level would be accomplished by draining Gatun Lake, except for pools behind the dams, in 11 days with interruption to ship traffic of 7 days. With the exception of portions of the present Canal which coincide with the alignment of the sea-level canal, the present lock Canal will be abandoned. The capacity of the proposed canal would be virtually unlimited, and it would handle the largest commercial ships and all aircraft carriers. Traffic could move in both directions simultaneously without interruption except where passage through a tidal lock is necessary. At this juncture, it has not been determined whether a tidal lock is necessary to compensate for tidal fluctuations at the Pacific side of the Canal.[27]

Political Problems. United States relations with Panama have been troublesome ever since the Hay-Bunau-Varilla Treaty was concluded in 1903. This treaty, which permitted the United States to construct, operate, maintain, and defend the Panama Canal, has been very unpopular with the Panamanians for most of the past 62 years. Two key words--sovereignty and perpetuity--in the treaty have been the constant irritants. One clause of the treaty gives the United States the right to act as if it were sovereign in the 10-mile-wide Canal Zone. The

other clause gives the United States rights to the Canal and the Zone in perpetuity. The Panamanians contend that the basic 1903 treaty was not negotiated or even signed by one of its own nationals, and that subsequent revisions of the treaty in 1936 and 1955 have not satisfied important national aspirations or recognized that Panama's geographical position, as its greatest natural resource, should be its primary source of income.

During the past ten years extreme nationalism in Panama, encouraged on occasion by the Communists, has resulted in violence and a deterioration of United States-Panamanian relations. In November 1959 anti-American riots were held in Panama City, and an attempted invasion of the Canal Zone by Panamanian Nationalists occurred. Flag-flying episodes in 1960 and 1963 in which the Panamanians attempted to plant their flag in the Canal Zone as a symbol of their titular sovereignty caused a further eruption in United States-Panama relations. The series of riots that occurred in January 1964 resulted in the wholesale destruction of American property and the loss of American lives and finally culminated in the suspension of diplomatic relations between the two countries.[28] Diplomatic relations were subsequently resumed, and the next politically significant event between the United States and Panama occurred on 18 December 1964 when President Johnson announced that the United States was prepared to renegotiate the 1903 Panama Canal Treaty. At a press conference on that date the President said, ". . . this government has completed an intensive review of policy toward the present and future of the Panama Canal. On the basis of this review, I have reached two decisions. First, that the United States should press forward with Panama and other interested governments in plans and preparations for a sea level canal in this area. Second, I have decided to propose to the government of Panama the negotiation of an entirely new treaty on the existing canal."[29]

Since the President's announcement in December 1964, the political climate between the United States and Panama has been reasonably calm, and representatives from both countries have been working diligently on a solution to the problem that has caused so much friction during the last five years.

The negotiations, which had been going on since December 1964, finally culminated in a partial

solution of the political problems confronting the United States and the Republic of Panama. The solution was expressed by President Johnson in a special announcement on 24 September 1965. At that time he said: ". . . In order to meet their present and future needs the two countries are negotiating separately a new and a modern treaty to replace the 1903 treaty and its amendments--a base rights and a status of forces agreement--and a treaty under which there might be constructed across Panama a new sea level canal." He added that with respect to the status of the negotiations on a new treaty to replace the 1903 treaty and its amendments, general areas of agreement have been reached.[30] The areas of agreement reached are the following:

1. The 1903 treaty will be abrogated.

2. The new treaty will effectively recognize Panama's sovereignty over the area of the present Canal Zone.

3. The new treaty will terminate after a specified number of years, on or about the date of the opening of the sea-level canal, whichever occurs first.

4. A primary objective of the new treaty will be to provide for an appropriate political, economic, and social integration of the area used in the Canal operation with the rest of the Republic of Panama.

5. Appropriate arrangements will be made to insure the rights and interests of the employees of all nationalities who are serving so efficiently and well in the operation of the Canal.

In addition, the President said that the new treaties will provide for the defense of the existing Canal and any sea-level canal which may be constructed in Panama. Further, the United States forces and military facilities will be maintained under a base rights and a status of forces agreement.

With respect to the sea-level canal, the United States will make studies and site surveys of possible routes in Panama. Furthermore, the present Canal and any new canal which may be constructed in the future shall be open at all times to the vessels of all nations on a nondiscriminatory basis. The tolls would be reasonable in the light of the contribution

of the Republic of Panama and of the United States of America and in the interest of world commerce.[31]

II—THE SEA-LEVEL CANAL

General Background. The idea for a sea-level canal across the American Isthmus was conceived about 400 years ago, shortly after Balboa discovered the Pacific Ocean. All of the early schemes to build a waterway to connect the Atlantic and the Pacific Oceans were sea level plans. The ill-fated DeLesseps Canal, the present site of the Panama Canal, was also a sea level plan. The United States considered building a sea-level canal in this area but eventually compromised for the present lock canal in Panama.

Some canal experts have been advocating a sea-level canal for years. It wasn't until the close of World War II, however, that the U.S. Government became involved in realistically evaluating the possibilities for a sea-level canal. Congress first authorized studies for a new canal in 1947, to be built at sea level, or with locks. More than 30 possible sites were investigated. In the early 1950's these were narrowed to 19. More recently, when it was determined that nuclear energy might be employed in excavation work, the choice was narrowed to five sites. The San Blas route located about 50 miles south of the Canal was eliminated from consideration last year because it was too close to the Panama Canal for a nuclear dig.

The first proposal to use nuclear earthmoving techniques to construct a sea-level canal dates back to 1957. In the Fall of that year, only a few months after the formal organization of the Atomic Energy Commission's Plowshare Program for the peaceful application of nuclear energy, President Eisenhower directed the Panama Canal Company to review plans for a sea-level canal, to study the needs for such a canal, and to evaluate and determine the means of construction and construction costs.[1]

Maj. Gen. William Potter, then Governor of the Canal Zone, proposed to include in his analysis the possibility of nuclear excavation and in the Fall of 1958 asked the AEC's Plowshare group to join him in the study. A report was prepared and submitted to the President in 1960. This report stated that a sea-level canal could not be economically justified in

the foreseeable future unless nuclear methods were used, and that the estimated costs for a nuclear-excavated canal were between $600 million and $1,200 million, depending on where it was located.[2] This is roughly about 50 to 90 per cent of the cost required for building a canal by conventional methods. Today, the Panama Canal Company, the U.S. Army Corps of Engineers, and the Atomic Energy Commission are working jointly on proposed plans for a sea-level canal. The choice, narrowed to four possible sites, includes a route passing through Costa Rica and Nicaragua, the Panama Canal location, the Sasardi-Morti route located about 110 miles south of the present canal in Panama, and the Atrato-Truando route in the northwest quadrant of Colombia. An orientation map showing the location of the four sites is shown in Appendix I.

Feasibility of Nuclear Excavations. The first study of the possibility of digging a sea-level canal with nuclear explosives was made in 1956 and 1957 by the Atomic Energy Commission. Additional experiments were conducted in 1959, 1960, and 1964. The results of these investigations indicated that digging a canal with nuclear devices was feasible and could be conducted safely.[3] However, blasting a channel across the isthmus with a row of buried nuclear charges designed to blow enough rubble out of a channel to leave it wide enough and deep enough for navigation is only one factor relating to the feasibility of building a sea-level canal with nuclear methods. Before a canal of this type can be constructed, additional cratering experiments to revise nuclear cratering technology will be necessary. There are still many uncertainties associated with determining the explosive yield required to produce a certain size crater. The scaling methods used to translate high-explosive, nonnuclear experiments into estimated nuclear effects might range in error from 250 to 300 per cent.[4] Furthermore, several studies, which are currently under way are needed to provide data on specific routes being considered. These studies include on-site surveys for the purpose of gathering information on topography, geology, hydrography, meteorology, hydrology, seismic effects, population distribution, and natural resources.[5]

The present "state of the art" in the peaceful application of nuclear explosives has progressed to a point in 1965 where costs in the development of nuclear devices have been reduced and where the effects of an underground nuclear detonation--

airblast, ground shock, and radioactive fallout--can be reasonably well-controlled.[6] The radioactive phenomenon, however, cannot be eliminated. Although predicted fallout patterns are 100 times less than they were during the 1958 tests in the United States, the fact that there would be some fallout in the construction of a nuclear-dug canal might prove to be a major stumbling block in the attempt to solve the Panama Canal problem by building an interoceanic waterway with nuclear devices.

Test Ban Treaty Implications. The 1963 nuclear test ban treaty which the United States signed with the Soviet Union and 100 other countries expressly forbids any underground nuclear blast which is likely to disperse radioactive debris beyond international boundaries. Despite the progress in the development of clean cratering techniques, every nuclear cratering detonation will release some radioactive material into the atmosphere. Therefore, the present test ban treaty imposes some restrictions on nuclear excavation. Consequently, conducting a large-scale nuclear excavation project such as a transisthmian canal would necessitate a modification of the treaty.

Dr. Glen T. Seaborg, Chairman of the Atomic Energy Commission, in a prepared statement before the Joint Committee on Atomic Energy on 5 January 1965, allowed that ". . . there are some cratering experiments necessary to develop excavation technology which can be conducted without violating the treaty, and that these experiments in the development of cleaner explosives may make it possible to conduct, under the treaty, additional cratering experiments which will advance excavation technology." He added that ". . . by allowing other nations to observe our experiments they would be able to observe for themselves the practicability, safety, and feasibility of using nuclear explosives for a large excavation project."[7] Dr. Seaborg also declared that, at this stage, he didn't know what the attitudes of foreign countries were with respect to using nuclear devices to build a sea-level canal in Latin America.

Creating international interest and cooperation in the peaceful application of nuclear energy appears to be a difficult undertaking at this point in history. Strong opposition to any type of nuclear experiments by "Ban the Bomb" groups and various non-nuclear nations could conceivably render a nuclear-dug canal project impracticable. Last March, the San Blas Indian chiefs, whose reservation is near

the Sasardi-Morti route, declared that their people would neither move nor ever assent to nuclear blasting which would "obliterate many of our 20,000 people, and make the remainder sterile."[8]

There is no assurance that the U.S.S.R. would agree to renegotiation of the test ban treaty, nor is there any assurance that the other 100 signatories to the treaty would release us from the test ban. Even if all of the parties to the treaty agreed to renegotiate a new treaty, a nuclear scare campaign by a recalcitrant Latin-American country could make our attempts to build a nuclear canal politically inadvisable.[9]

Financial Aspects. Preliminary cost estimates for the construction of a sea-level canal range from about $770 million for the cheapest nuclear canal at the Sasardi-Morti route to $2.3 billion for the conversion of the Panama Canal by conventional methods. The cost for the Atrato-Truando route in Colombia, which includes both nuclear and conventional means of construction, is $1.4 billion, and the cost for the Costa Rica-Nicaragua route by nuclear methods is $1.9 billion.

These costs are based on 1947 and 1960 data. The estimate for converting the present Panama Canal to sea level does not include the charges for a tidal lock which may be required. Furthermore, the cost estimates for nuclear canals in Panama, Colombia, and Costa Rica-Nicaragua have been reduced since 1960. The Atomic Energy Commission recently made the nuclear approach more attractive by reducing the required explosive yield to dig a canal by 50 per cent. Cost estimates for general construction aspects and other contingencies have also been reduced. An example of the reduction in costs is the 1965 estimate for the construction of the Sasardi-Morti route in Panama. The AEC claims that this route could be constructed for $650 million, which is about $120 million less than the 1960 estimate.[10]

In summary, these cost estimates do not include a number of charges which should be considered in any estimate for the construction of a sea-level canal. For example, the price a host nation might ask to allow the United States to build a canal in its territory; the redress the United States would have to pay Panama if the canal is located elsewhere; the cost of new defense bases and other facilities, such as roads, housing, power-generation

installations, port facilities, high-level bridges over the new waterway; a recent $17 million authorization by the Congress to conduct on site surveys; and the millions of dollars the AEC is using to refine the techniques which will be utilized in constructing the canal are some of the major elements which should be considered when the final cost for the construction of a sea-level canal is estimated.[11] In the final analysis it is conceivable that the cost of converting the present canal to sea level by conventional methods would be approximately the same as the total cost for a nuclear-dug canal.

Political Considerations. Any political analysis concerning the construction of a sea-level canal across the American Isthmus should consider Latin America's past history of constant political upheaval and change and the temperament of the people in the area. It is doubtful, indeed inconceivable, that Colombia, Nicaragua, Costa Rica, or even Panama would sign away sovereignty or perpetuity rights for a canal in their countries no matter what price was offered. Moreover, if the United States insists on defense of a proposed canal within the national territory of the country finally selected for the canal, the establishment of military bases could become a major issue. Nationalism is so rampant in Latin America that few Latins would welcome the prospect of U.S. troops on their soil. Many Latin Americans think that we have used Panama for the last 60 years and now find that Panama is no longer of any use to us. In seeking another route for the canal they believe that we are merely playing the countries off against one another, and have concluded that the same thing could happen to them if they were in the same position as Panama.

Both Nicaragua and Costa Rica are opposed to an internationalized canal, and each country is adamant about no military bases. In addition, Nicaragua insists that the hated Bryan-Chammoro Treaty of 1916, which gives the United States perpetual rights to build a canal through Nicaragua, be abrogated.[12] The Colombians appear to have a "take it or leave it" attitude. A public works official in this country recently stated that ". . . we would be happy to have the canal, but we won't starve without it." He added that ". . . the law of supply and demand can be applied to Colombia. We are a big country. We would not depend on the canal for our economic development but we have something to sell. So let us see what the United States is prepared to offer."[13]

The Panamanians think the United States has a moral responsibility to build the sea-level canal in Panama. They have also demanded that on the day the new canal is opened the United States should return to Panama the entire Canal Zone, complete with its hundreds of public buildings, homes, schools, hospitals, utilities, highways, piers and docks--all gratis--plus pledged U.S. aid in developing the vast canal facilities into a hydroelectric or industrial project. Furthermore, if the new canal is dug through Panama, Panamanians want the United States to hand it over to them free and clear once the cost of building it has been amortized.[14]

From the foregoing it can be concluded that, more than anything else, political factors will be the overriding consideration in the construction of a sea-level canal, for no matter where the canal is finally constructed, the U.S. will be confronted with many of the political problems it has today with the Republic of Panama and the present canal.

III--ALTERNATIVES

General. Whichever route is chosen, once construction work begins a new sea-level canal could be ready for operation within ten years. The on-site surveys, which are currently in progress, should be completed in 1967 or 1968. If a site is selected in 1968 and construction work commences, the sea-level canal could be operative before 1980. The four choices or alternatives, already identified in this paper--the two routes in Panama, the Nicaragua-Costa Rica route, and the Colombia route--would have a number of common advantages. First, a sea-level canal located at any of these sites would permit the passage of any vessel afloat today, or for that matter, probably any vessel built in the future; second, the elimination of locks would allow ships to transit the waterway with little, if any, delay; third, fewer personnel--about 500 persons, as contrasted with 14,000 persons at the Panama lock canal --would be required to operate a sea-level canal; and fourth, the sea-level canal would be less vulnerable than a lock canal to sabotage. The principal features of the four routes are tabulated in Appendix II.

A brief examination of each route and an enumeration of the factors favoring or militating against the selection of the route for a sea-level canal follows:

The Panama (Canal Zone) Route. This alternate, the only nonnuclear route being considered, is the shortest route with a total length of 46 miles. Surveys and engineering plans to convert the present canal to sea level have been completed, and estimated costs made in 1960 are still valid in 1965. The estimated costs approximate $2.3 billion for a waterway without a tidal regulating lock, which might be required. The cost of the canal with the lock is about $2.5 billion.[1] Essentially, the proposed canal will follow the alignment of the present canal, utilizing portions thereof which coincide with the sea level alignment. Proposed channel dimensions are 600 feet in width and 60 feet in depth. The excavation of over a billion cubic yards of rock and earth would be done in such a way so as not to interfere with Panama Canal traffic. This would be accomplished by leaving water-retaining natural rock dikes in place to maintain canal levels during the excavation. When the earth-moving work is complete, the dikes would be progressively demolished by blasting them into deep adjacent pits excavated in advance. The changeover from lock canal to sea-level canal would be accomplished by draining Gatun Lake, except for pools behind the dams, in 11 days with interruption to ship traffic of seven days. This would be the only time during the 10-to-12-year construction period that canal traffic would be disrupted.[2]

The advantages afforded by the Canal Zone site are largely political. Even with the recent modification of the 1903 treaty, the United States still has a good foothold in Panama. If the two countries are unable to resolve differences the United States still has the right, under the 1903 treaty, to construct a sea-level canal at the site of the present canal. The method of construction precludes the necessity of renegotiating the test ban treaty. Further, although status of forces and defense base rights are on the agenda for further discussion, in all probability, the United States will retain defense bases and forces in the Canal Zone if a sea-level canal is built at this location. Additional advantages include the following: This route is the shortest being considered; lengthy surveys would not be needed since the U.S. Army Corps of Engineers already have almost all of the required data to convert the present canal; machinery and other equipment are on hand or could be easily brought in at the terminal facilities at either end of the canal; and, finally, the location of the new canal at this site will eliminate the necessity for the United

States to provide redress or sizeable grant in aid to offset economic disruption in Panama if the canal is located elsewhere.[3]

The disadvantages of locating the canal at this site are largely financial, but also political. This is the most expensive route under consideration. It is about seven or eight times the cost of the cheapest-dug nuclear canal. The still unsolved problem of the tidal lock would make the route more vulnerable than a sea-level canal without a lock, and the politically emotional issue of the 1903 treaty may erupt again and force the United States to dig the canal elsewhere.

The Panama (Sasardi-Morti) Route. To those who advocate the use of nuclear devices to build a sea-level canal, this route would win hands down if atomic energy could be used. At an estimated cost of $650 million it is the least expensive route under consideration. It has a total length of 48 miles, the second shortest route of the four alternatives. The nuclear cut would require 300 nuclear charges ranging in individual yield from 100 kilotons to 10 megatons, with a total yield for all charges of 170 megatons. To emplace the charges would require drilling 300 holes with cased diameters of 36 inches for the smaller yields and 54 inches for the larger yields, and depths ranging from 550 to 3,130 feet. The ten-megaton devices would be used at the highest elevation points along the continental divide.[4]

This project would be divided into three phases. The first phase, feasibility and site-selection surveys, would require about three years. The second phase, engineering surveys and design, would begin after Congress had authorized construction and a treaty with the host country had been obtained and ratified; estimated time for this phase is about one year. The third phase, the actual construction of the waterway, would take about six years. Estimated time to complete the entire project is ten years.[5]

One of the major advantages of this site is its location, 110 miles south of the Panama Canal in a sparsely populated area which satisfies one of the principal criteria for the use of nuclear explosives.[6] Tidal fluctuations could be minimized, inasmuch as the proposed canal would be 1,000 feet wide with center depths ranging from 300 to 380 feet; minimum channel depths would be 60 feet. Construction time for this project is the shortest for any

route being considered, and, as previously stated, this route is the least expensive.

Some of the major factors militating against the route include the uncertainties associated with nuclear effects, primarily but not exclusively the fallout problem; the necessity for modifying the test ban treaty; the requirement to negotiate for a strip of land to build the canal, and other treaty arrangements; the need for relocating, for periods up to three years, about 25,000 inhabitants; and the objections of some shipping companies who claim that the additional sailing time to this canal would increase their operating costs by $4,000 or $5,000. Furthermore, a tidal lock might be required at the Pacific end of the canal. If a lock is necessary, nuclear explosives could not be used in the vicinity of its eventual location.[7]

The Colombia (Atrato-Truando) Route. Both nuclear and conventional methods would be used to construct this route. It has a total length of 102 miles with the right of way lying entirely within the territory of Colombia. Approximately 25 miles of the route parallels the Atrato River in a low alluvial terrain which is subject to flooding. Total cost of the route is about $1.4 billion. The length of the nuclear cut is about 43 miles. The number of nuclear charges required will approximate 260, with the lowest yield measuring 100 kilotons and the highest 10 megatons, and the total yield aggregating 270 megatons.[8] Over a billion cubic yards of material will be dredged by conventional methods, and the channel dimensions will range from 1,000 feet in the nuclear cut to 600 feet in the conventional cut. Minimum channel depths throughout the entire length of the waterway will be 60 feet.

This project will be accomplished in phases similar to the Sasardi-Morti route. Total time required to complete the project is estimated at 13 years with nine years devoted to actual construction work.

The advantages afforded by the Atrato-Truando route are generally the same as those offered by the Sasardi-Morti route.

The disadvantages of this route include most of the factors associated with the Sasardi-Morti route. However, if this route is selected approximately 60,000 inhabitants will have to be temporarily

relocated. Moreover, the shipping companies who object to the additional costs involved in extra sailing time to the Sasardi-Morti route would have stronger objections to this route; the tidal lock problem is also applicable at this location.

The Nicaragua-Costa Rica (Greytown-Salinas Bay) Route. With a total length of 168 miles and an estimated cost of $1.9 billion, this is the longest route being considered and the most costly nuclearwise. The number of nuclear charges required to blast a trench for the canal approximates 957. Yields range up to 20 megatons.[10] The continental divide elevation here is only 760 feet, which might make the nuclear cut at this location less difficult than at other sites where elevations are approximately 1,000 feet or more.

The only major advantage afforded by this alternate is its proximity to the United States, which would cut shipping time between the Pacific and U.S. Gulf and Atlantic ports.

Planning a canal at this location has several disadvantages. A route that touches two countries makes doubly difficult the task of working out treaty arrangements. Further, the canal alignment passes so close to so much of Nicaragua's population and industry, that a substantial portion of the population and industry would have to be temporarily relocated. Lake Nicaragua, a national shrine in that country, could not be utilized in any way for a sea level route in this area. Finally, the recent nationalization of all lands bordering the San Juan del Norte River in Costa Rica, along which the proposed canal is routed, could effectively eliminate this alternative from further consideration.[11]

IV-CONCLUSIONS AND RECOMMENDATIONS

The Panama Canal has served the United States and the world well for the past 50 years. Panama is one country that really wants the new canal and is desperate to get it. The United States can ill-afford to build the canal elsewhere and let Panama go down the drain. A change of site could cost the United States several millions of dollars in reparations, transform the terminal cities of Colon and Panama City into ghost towns, and turn the Republic of Panama into "just another Banana Republic."

It is highly unlikely that the United States can obtain more favorable treaty arrangements with other countries than it has with Panama, and it can well afford to be more generous with Panama than it has been, despite political differences.

The location of the new sea-level canal within the Canal Zone will eliminate the necessity for negotiating for a modification of the test ban treaty, for real estate to build the new canal, and for other treaty arrangements which could, in the last analysis, disrupt the status quo in Central America and place the United States in an unfavorable political position vis-à-vis Latin America.

Since the cost of construction does not weigh too heavily in making the choice of the route, since President Johnson has already modified the hated 1903 treaty, and because the United States is still firmly entrenched in the Canal Zone, the conversion of the existing canal to sea level appears to be the best possible solution.

Finally, it should be noted that the Canal Zone route would be the least expensive conventionally-built route and that until nuclear techniques for digging transisthmian canals, which are still in the experimental stage, are more sophisticated, we should, at this stage, construct a sea-level canal by conventional methods.

For these reasons, it is recommended that the best interests of the United States will be served by converting the present Panama Canal to sea level.

FOOTNOTES

I--The Panama Canal

1. Norman J. Padelford, *The Panama Canal in Peace and War* (New York: Macmillan, 1942), p. 2.

2. *Ibid.*, p. 3.

3. Earl Harding, *The Untold Story of Panama* (New York: Athene Press, 1959), p. 3.

4. Padelford, p. 12.

5. *The Panama Canal, Funnel for World Commerce* (Balboa Heights, C.Z.: n.p., 1964).

6. "Dig We Must," *Time*, 25 December 1964, p. 16.

7. U.S. Congress, House, Committee on Merchant Marine and Fisheries, *A Long-Range Plan for Isthmian Canal Transits*, Report (Washington: U.S. Govt. Print. Off., 1960), p. 11.

8. "Cargo Gains Made by Panama Canal, Now 50 Years Old," *The New York Times*, 19 December 1964, p. 11:8.

9. "How to Make Good without the Canal," *Time*, 1 January 1965, p. 31.

10. Mortin B. Travis and James T. Watkins, "Control of the Panama Canal: an Obsolete Shibboleth?" *Foreign Affairs*, April 1959, p. 407.

11. Alfred T. Mahan, "The Panama Canal and the Distribution of the Fleet," *North American Review*, September 1914, p. 416.

12. U.S. Congress, House, Committee on Foreign Affairs, *United States Relations with Panama*, Report (Washington: U.S. Govt. Print. Off., 1960), p. 12.

13. August C. Miller, Jr., "Prognosis for the Panama Canal," *United States Naval Institute Proceedings*, March 1964, p. 70.

14. House, Foreign Affairs Committee, *United States Relations with Panama*, p. 91-94.

15. Travis and Watkins, p. 407.

16. *Ibid.*, p. 410.

17. *Ibid.*, p. 410.

18. House, Foreign Affairs Committee, *United States Relations with Panama*, p. 97.

19. Hanson W. Baldwin, "New Defense Role for Canal Shown," *The New York Times*, 28 April 1957, p. 26:1.

20. U.S. Congress, Senate, Committee on Commerce, *Second Transisthmian Canal*, Hearings (Washington: U.S. Govt. Print. Off., 1964), p. 10.

21. House, Committee on Merchant Marine and Fisheries, *Long-Range Plan*, p. 11.

22. Panama Canal Company, *Annual Report of the Board of Directors* (Balboa Heights, C.Z.: 1959), p. 13.

23. Panama Canal Company, Canal Zone Government, *Annual Report* (Balboa Heights, C.Z.: 30 June 1964), p. 29.

24. House, Committee on Merchant Marine and Fisheries, *Long-Range Plan*, p. 25-31.

25. *Ibid.*, p. 25-31.

26. *Ibid.*

27. *Ibid.*

28. Miller, p. 69.

29. "Dig We Must," p. 16.

30. "Panama to Obtain Canal Control," *The Providence*, (Rhode Island) *Journal*, 25 September 1965, p. 3:1.

31. *Ibid.*

II--The Sea-Level Canal

1. U.S. Congress, Joint Committee on Atomic Energy, *Peaceful Applications of Nuclear Explosives--Plowshare*, Hearings (Washington: U.S. Govt. Print. Off., 1965), p. 471.

2. *Ibid.*, p. 472.

3. Senate Committee on Commerce, *Second Transisthmian Canal*, p. 40-41.

4. Joint Committee on Atomic Energy, *Plowshare*, p. 437.

5. Senate Committee on Commerce, *Second Transisthmian Canal*, p. 41.

6. Joint Committee on Atomic Energy, *Plowshare*, p. 371.

7. *Ibid.*, p. 10-33.

8. Clarence W. Hall, "Where Shall We Build the New Canal?" *The Reader's Digest*, September 1965, p. 216.

9. *Ibid.*

10. Joint Committee on Atomic Energy, *Plowshare*, p. 472.

11. James H. Stratton, "Sea-Level Canal: How and Where?" *Foreign Affairs*, April 1965, p. 514.

12. George Natanson, "Latin Shrugs Greet Our Talk of New Canal," *The Washington Post*, 7 February 1965, p. E5:6.

13. *Ibid.*

14. Hall, p. 220.

III--Alternatives

1. House, Committee on Merchant Marine and Fisheries, p. 31.

2. Stratton, p. 516.

3. Hall, p. 216.

4. Joint Committee on Atomic Energy, *Plowshare*, p. 367.

5. *Ibid.*, p. 373.

6. Senate Committee on Commerce, *Second Transisthmian Canal*, p. 36.

7. Joint Committee on Atomic Energy, *Plowshare*, p. 462.

8. *Ibid.*, p. 367.

9. Senate Committee on Commerce, *Second Transisthmian Canal*, p. 18.

10. Joint Committee on Atomic Energy, *Plowshare*, p. 461.

11. Natanson, p. E5:6.

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